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ABSTRACT

Information concerning reading skills that must be developed concomitantly with fundamental mathematical concepts is provided in this paper designed for elementary school mathematics teachers. The relation of basic computation skills to vocabulary developments and specialized reading skills is discussed. Teaching suggestions are illustrated by sample problems in many areas including: the use of flash cards, mathematical writing, the language of algebra, a translation of sentences into algebraic equations, open sentences, understanding formulas, translating symbols, drawing conclusions, estimating reasonable answers, and using diagrams. (MKM)

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MATHEMATICS SUPPLEMENT TO

A MINI-GUIDE TO READING IN THE CONTENT AREAS

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Prepared by
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Division of Instruction

INTRODUCTION

The purpose of this paper is twofold. The primary purpose is to present ideas to elementary grade teachers which will help them to teach mathematics better. The secondary purpose is to make upper level teachers more aware of students' needs for reading skills which lead to better mathematics comprehension and achievement. It is recognized that many upper level students are lacking in both reading and mathematics skills and that teachers, being aware of this, can be more effective in ameliorating the mathematics weakness by remediating the reading weakness. Also, good students need to continue to develop careful and critical reading habits in mathematics.

Mathematics is a subject which requires highly specialized reading skills. Any treatise on the entire field of mathematics would be voluminous, therefore this paper will focus on reading and mathematics in the elementary school. The supposition is that if students at the elementary level are taught the fundamental concepts and reading skills necessary for achievement at the basal level, there will be carry-over learning for continued achievement at the upper levels.

This paper will deal with three fundamental skills: (1) basic computational skills, (2) vocabulary development, and (3) reading word problems.

NOTE: Although numerals are symbols, in this paper the word numeral(s) will be used to refer to number(s) concepts, and the word symbol will refer to signs of operation and other special devices used in connection with mathematics calculation and manipulation.

Teachers must teach the symbols of mathematics, the numerals and the signs of operations. They must teach literal meaning and implied meaning of the written or spoken word in translating words into mathematics expressions or sentences. Students must learn to be careful, analytical and interpretative readers.

Students must be able to respond correctly to symbolic expressions such as divide ($2\overline{)16}$), square root ($\sqrt{64}$), or exponential functions such as two cubed (2^3). The combination of numerals and symbols "tells" what is to be done, and the students must be able to properly "read" the symbolic messages. The value of each of these expressions is 8, but the answer is arrived at differently in each case.

A mathematical sentence such as, $X^2 + 6X + 9 = 0$, can be pronounced (read) by primary students, but the implied operations, factoring and solving, must be "read into" the sentence by more advanced students in order to arrive at a solution. Another reading skill is that of actually reading or hearing words and translating the words into correct mathematics phrases or sentences to be evaluated or solved. In this respect, mathematics is a sort of specialized shorthand. In the mathematical shorthand form it becomes a universal language which bridges cultural and language barriers.

Reading of or in mathematics involves more than just reading words. The highly symbolized nature of the subject makes it unique. One must know not only how to read, but also how to interpret and solve mathematical sentences and

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phrases, maps, charts, formulas, and graphs--all having mathematical connotations or meanings. Then, too, words must be translated into number sentences or phrases to be solved or evaluated. Conversely, symbolic expressions must be translated and interpreted in light of given or known data.

Essentially, reading in mathematics involves: Learning vocabulary (symbolic and literal), translating words to symbols and vise versa, and reading verbal problems to determine what is known, what is asked, and how to set up and solve the problems.

BASIC COMPUTATIONAL SKILLS

The brevity of this section on computational skills must not be construed to mean that it is unimportant. On the contrary, computational skills are fundamental, but are generally learned without a great deal of reading involved. Early arithmetic is primarily teacher-structured, and the important point to teachers is that they teach the simple meanings of numerals and symbols. More reading, more complex problems, and better understanding are based on knowing the basic computational skills.

Mathematics is unique in that initial instruction is oral-symbolic. Preschool and primary textbooks or workbooks use symbols of operations for addition and subtraction and symbols of equality and inequality before the students are actually able to read. There is little or no explanatory writing, per se, in primary texts. The teacher explains what is to be done and guides the learners in counting, combining, comparing, and ordering. These are all operations of a sort, and as the scope and sequence expands additional operations are introduced.

By whatever means, (depending on the text or method being used) the teacher must teach the basic operations of addition, subtraction, multiplication, and division. While this is being done vocabulary elements enter the picture. These are the symbols and the descriptive words used for the symbols.

VOCABULARY DEVELOPMENT

Preschoolers are usually exposed to and do learn many number facts without the teaching of mathematics being intended or considered. Some early number usage is quantitative, some qualitative. Children usually want "one" or something or they want to be "first" in some activity. They use the cardinal and ordinal numbers without being aware of the concepts. The power and order of numbers may not extend beyond counting to 5, 10, or 20, and being second, third, or "last" means an undesirable place for them in some ongoing activity.

Then school comes and along with it comes counting and ordering, and things called numerals enter the picture. Before long, funny looking things called plus signs (+) indicate amounts are to be added. Symbolism of mathematics has begun. Moreover, words are used by the teacher or in the book and these words have to be changed to numerals and symbols. Interpretation has begun. Sometimes the student must "read" a mathematics expression, saying in words what has been expressed in numerals and symbols. Translation has begun.

The symbolic vocabulary of mathematics and its translation can be confusing

to students and care must be exercised in using and explaining the symbols. The more usual symbols are +, -, x, ÷, =, ≠, <, >, ≤, ≥, ∤, ∦, $\sqrt{\ }$, ( ), ·, and ⌐. The / or the line —— used to denote fractions also comes into use in primary grades. Later there are many other symbols.

If each of these symbols had only one definition or descriptive name, students could learn them more easily and without ambiguity. This is not the case however. Vocabulary and symbols occur simultaneously. For example, for a problem such as 3 + 2 = □, one teacher may say "do this problem," another will say "work" this problem, or "solve" this problem, "add these numbers," or "find the sum," and so on. There is no standard translation attached to the symbol. (In the instructional model in a later section you will have an opportunity to assign various expressions to these symbols.)

Within the mathematics field there are hundreds of terms which are more or less technical and unique to the field. Some terms and expressions which are representative of those found in the elementary school arithmetic materials are:

add	fraction	per cent
angle	lowest term	perimeter
circle	minuend	quotient
computation	mixed number	ratio
cube or square root	multiplicand	rectangle
decimal	multiply	square
denominator	numerator	subtract
divide	ordinal	subtrahend
divisor	partial product	triangle
factor		

These terms should be taught in conjunction with operational use of the term in mathematics expressions or problem solving.

Another problem faced by the student in vocabulary development is that of using words having multiple meanings. A sample list of such terms is as follows:

area	produce	set
cardinal	radical	solution
difference	reduce	table
foot	root	scale
mean	round	yard

With the advent of metric education there comes a new and specialized vocabulary. Actually, introduction of metric terminology will tend to simplify the quantitative memorization of large and small unit relationships such as done in the customary measurement system. This is because the multiple and submultiple prefixes used with the base units of the metric system are constant in value regardless of the base unit being prefixed. The compound words formed by affixing the repetitive prefixes to base units afford an excellent language arts tie-in with the study of other compound words.

The most practical instructional metric units for elementary grades are meter for length, liter for capacity or volume, and gram for mass or weight. There

are many prefixes signifying larger and smaller multiples of the base unit, but the six most useful for elementary instruction are:

kilo for 1000 times the base unit
hecto for 100 times the base unit
deka for 10 times the base unit
deci for 0.1 times the base unit
centi for 0.01 times the base unit
milli for 0.001 times the base unit

The interrelatedness of the metric units lends itself to meaningful exercises in word and symbol translation, and implied meanings for comparable units such as milliliter and cubic centimeter.

The need for a mathematics vocabulary continues to grow, not only during the formal educational experiences of the student, but even more so through living in a world of applied consumer and technical mathematics.

A few basic suggestions to teachers for developing students' mathematical vocabulary:

1. Speak, write, and use numerals and symbols clearly, concisely, and consistently and teach students to do likewise.

2. Explain and demonstrate mathematical ideas as simply as possible, and then extend understanding of terms, symbols, and numerals by use of synonyms, parallel expressions, and implied meanings.

3. Teach students to recognize the contrast between the mathematical meanings of words or expressions and their meanings in other areas of study.

4. Provide opportunities for study of new words or terms and of how they will be used in mathematics.

5. Teach students to use glossaries and dictionaries for pronunciation, spelling, and definition of mathematics terms.

6. Provide opportunities for students to read mathematics--to read mathematics words, to read and interpret symbolic expressions, to translate symbolic forms into words.

7. For beginning or slow learners keep instruction simple. Above all, remember that to be "worked" mathematics has to be "read and understood."

READING WORD PROBLEM

Teachers at all grade levels frequently tell students to "read the problem." This section deals primarily with activities which will sharpen students' comprehension of word problems.

1. Students should learn to read for the main idea in a problem, to recognize what is being asked in the problem. What is the unknown?

2. What are the pertinent facts? What is the irrelevant information? Discard the irrelevant and study the sequence and connection between the pertinent data. Write down these data.

3. Convert words and number facts into symbolic-numeric phrases.

4. Draw figures, charts, or graphs to represent the given data, and formulate number sentences (equations) and solve for the unknown. If a formula is to be used, substitute pertinent data in the formula and solve.

From Reading in the Content Area, a monograph published by the International Reading Association, Glennon and Callahan (1968), after reviewing a number of studies on research in problem solving, concluded that the following four factors were most important for success: 1) general reading skills, including vocabulary; 2) problem-solving reading skills, including comprehension of the problem statement, selection of relevant details, and selection of the proper solution procedure; 3) mechanical computation and a mathematical understanding of the concept of quantity, the number system, and important arithmetic relationships; and 4) a spatial factor, involving the ability to visualize and conceptualize objects and symbols in more than one dimension and to use mental imagery to clarify word meanings (p. 83).

INSTRUCTIONAL MODELS

There are many ways to teach and to reinforce reading in the area of mathematics. In the suggestions which follow the instructional heading is shown with typical examples, however more examples can be developed depending on the topic being taught.

A. Test for Mathematical Writing

Directions: Complete the statements below.

1. The verb phrase 'is greater than' is represented by the symbol

   a. $<$
   b. $>$
   c. $\neq$
   d. $\leq$

2. In the formula $C = 2\pi r$, the 2 means

   a. squared
   b. second power
   c. increased by 2
   d. twice

3. 15 diminished by X is written mathematically as

a. X - 15
b. X + 15
c. 15 - X
d. 15 + X

B. Flash Cards and Sight Words

Use flash cards with mathematical symbols or terms on one side and definitions on the other side. The teacher may show either side and students respond appropriately. Use terms applicable to the on-going instruction or for review.

C. Matching of Definitions or Signs of Operation

Directions: Find the symbol in column II that matches the word or words in column I. Write the correct answer.

Column I		Column II
_____	a. increase by	+
_____	b. difference	
_____	c. quotient	–
_____	d. sum	
_____	e. diminished by	
_____	f. decrease by	x
_____	g. more than	
_____	h. remainder	
_____	i. product	÷
_____	j. less	

D. Algebraic Language

Directions: In mathematics we need to learn the meanings of words and symbols just as we do in the English language. Match the definitions in column II with the symbols in column I by writing a letter in the appropriate blank.

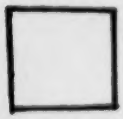
Column I		Column II
_____	1. =	a. is greater than
_____	2. >	b. square root
_____	3. ≤	c. is greater than or equal to
_____	4. ≠	d. is equal to
_____	5. ≯	e. is not less than
_____	6. <	f. is less than or equal to
_____	7. ≥	g. is less than
_____	8. ≮	h. is not equal to
_____	9. √	i. is not greater than

Directions: Match the definitions in column II with the words and phrases in column I by writing a letter in the appropriate blank.

Column I	Column II
_____ 1. unknown	a. number shown by means of a base and an exponent
_____ 2. open sentence	b. variable
_____ 3. term	c. any mathematical writing
_____ 4. expression	d. name given to each of two numbers to be multiplied
_____ 5. factor	e. expression used as a factor
_____ 6. sentence	f. terms that do not have the same variable factors
_____ 7. power	g. expression written as a product of numerals and/or variables
_____ 8. like terms	h. terms that have the same variable factors
_____ 9. exponent	i. indication of how many times the base is to be used as a factor
_____10. unlike terms	j. expressions which name a number
_____11. base	k. mathematical writing which expresses a complete thought
_____12. phrase	l. sentence which includes an unknown

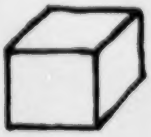
E. Unit Vocabulary

Directions: Write the units below that you would use to find the items which follow them.



square region

line segment



cube

1. length of a rope_____
2. area of a floor_____
3. the volume of air in classroom _____
4. the distance to school _____
5. the size of your belt _____
6. the volume of your refrigerator _____
7. the size of your hat _____
8. the height of your best friend _____
9. the size of a photograph _____

F. Translating English Sentences to Algebraic Equations

Directions: Translate the following English sentences into mathematical sentences. Some problems require symbols for grouping. Example: Six more than 3 times a certain number is 18. $3n + 6 = 18$.

1. A certain number added to 5 equals 11. _____

2. 3 times a number equals 12. _____
3. If 7 is subtracted from a certain number, the result is 3. _____
4. A number increased by 12 is equal to 32. _____
5. The product of a certain number and 12 is 20. _____
6. 11 less than a certain number is 19. _____
7. 2 more than 5 times a certain number is greater than 42. _____
8. The area of a rectangle is equal to the length times its width. _____
9. 3 less than 5 times a number is 17. _____
10. The area of a triangle is equal to 1/2 its base times its height. _____

G. Using Open Sentences

Directions: An open sentence is one which cannot be called true or false until the value of a missing number is known. Which of the following is an open sentence?

1. $\frac{2}{?} = 18$
2. $2 \times \square = \frac{3}{5}$
3. $15 - ? = 0.6$
4. $8 \times \square = 42$
5. $8 \times 3 = 24$

Directions: An open sentence has the missing number represented by a place holder. The preferred place holder is a letter. Rewrite each of the following with the letter y as a place holder.

1. $7 + ? = 26$
2. $9 - 2\frac{1}{6} = ____$
3. $\blacksquare : 4 = 22$

Directions: Suggest a value for the letter which would make each open sentence true.

1. $n + 4 = 11$
2. $6 \times \square = 42$
3. $50\% \times 40 = n$
4. $y - 2 > 7$
5. $15 \neq n + 2$
6. $10\% \times n = 8$
7. $\frac{n}{2} = 8$
8. $12 > n = 4$

H. Translating Mathematics to English

Directions. Write the letter of the answer that is a completely correct translation of the phrase or sentence.

1. $12 - 3$
   a. 12 less 3
   b. 12 is less than 3
   c. 12 less than 3
   d. 12 subtracted from 3

2. $18 \geq 5$
   a. 18 greater than 5
   b. 18 more than 5
   c. 18 exceeded by 5
   d. 18 is greater than or equal to 5

3. 6.7
   a. 6 and 7 tenths
   b. 6 of the 7's
   c. 6 to the 7th power
   d. base 6 with exponent

4. 8 + 9
   a. 8 decreased by 9
   b. 8 increased by 9
   c. 8 diminished by 9
   d. 8 increased to 9

5. $16 \neq 17$
   a. 16 is not equal to 17
   b. 16 is not less than 17
   c. 16 is greater than 17
   d. 16 is not greater than 17

I. Formula Comprehension

Directions: Write the following formulas as answers to the questions below:

$A = \ell w$	$P = 2\ell+2w$	$V = \ell wh$
$A = s^2$	$P = 4s$	$V = e^3$
$A = \pi r^2$	$C = \pi d$	$E = \frac{I}{R}$
$A = \frac{1}{2}bh$	$C = 2 \pi r$	$P = br$
$A = \frac{1}{2}h(a+b)$		$P = 2(\ell+w)$

Which formulas:

1. Use *pi*, the Greek symbol which represents the approximate value 3.14?
2. Use the distributive law with factor 2 multiplying all addends?
3. Contain a factor raised to the third power?
4. Contain division by 2?
5. Have all numbers represented by letters?
6. Have a number which means twice or double?
7. Contain a cubed number?
8. Use a parentheses?
9. Use exponents?
10. Contain a factor called a squared number?

Directions: Write *true* or *false* for the following:

11. In the formula $A = \ell w$, A holds the place for the measure of altitude.
12. $C = 2\pi r$ can be written $2\pi r = C$.
13. ℓw can be written $w\ell$.
14. $A = \frac{1}{2}bh$ is the same as $A = \frac{bh}{2}$.
15. $P = 2\ell + 2w$ is the same as $P = \frac{1}{2}(\ell + w)$
16. The usual approximation for π is 3.

J. Symbol Translation

Directions: After reading the following expressions carefully, write in the blank whichever symbol (or symbols) matches the underlined words. Use only the symbols +, -, x, or ÷.

Example: 5 added to 4 __+__

1. 3 added to 6 _____
2. 12 increased by 4 _____
3. 9 less than 12 _____
4. The difference between 15 and 8 _____
5. The product of 6 and 3 _____
6. The sum of 4 and 9 is greater than 3 _____
7. The quotient of 12 and 4 _____
8. 5 increased by 24 _____
9. 12 less than a _____
10. 10 times the difference of a and 4 _____
11. The quotient of 6 and 3 increased by 2 _____
12. The sum of a and 5 decreased by their product _____

Directions: Translate the following phrases into symbols. *Example:* The quotient of 15 and 8: $\frac{15}{8}$ $8\overline{)15}$

1. The sum of 6 and 5 _____
2. The difference between 20 and 12 _____
3. 17 more than 10 _____
4. The quotient of 21 and 3 _____
5. The square root of 100 _____
6. The product of 7 and 8 _____
7. The difference of 9 and 4 increased by $\frac{1}{3}$ _____
8. The sum of 3 and b increased by 5 _____
9. 3 less than $\frac{1}{3}$ of a _____
10. The difference between $2a$ and 5 _____

K. Reading, Selecting, and Evaluating

Directions: Write the number which satisfies all conditions listed.

1. What number is
   a. an even number
   b. divisible by 3
   c. less than 50
   d. greater than 6 x 6
   e. a multiple of 7

2. What number is
   a. between one and one hundred
   b. larger than 50
   c. an odd number
   d. not a multiple of 3
   e. not smaller than 70
   f. less than 80
   g. a multiple of 7 when its digits are added

L. Drawing Conclusions

Directions: For each problem listed below tell what you need to know. Then tell what to do to solve the problem.

1. Althea wants to know the average score of her arithmetic tests.
   She needs to know _____.
   She solves the problem by _____.

2. Paul wants to know the cost of Cokes for the class party.
   He needs to know _____.
   He solves the problem by _____.

M. Relevant and Irrelevant Data

Directions: Carefully read the problems below. Write the answers to the questions.

1. Connie bought a pack of 10 pencils for $.72. She gave the clerk $1.00. How much change should she receive?
   Answer:_____ Extra number _____

2. On Wednesday 32 of the 35 students in Edna's class were present. 17 boys were present. How many girls were present?
   Answer:_____ Extra number _____

N. Estimating Reasonable Answers

Directions: Carefully read the information below. Write the answers to the questions.

1. Plants for the classroom aquarium cost $1.49. Fish cost $.63. How much did the class pay in all for the plants and fish?

2. Last month the school's science department bought 25 white mice at $1.08 each. How much in all did the mice cost?

O. Reading Creatively

Directions: Carefully read the problems below. Set up the problem to answer the question.

1. Sue saved $3.54. She earned $.75 more by baby-sitting. How much does she still need to buy a sweater that costs $7.95?

$3.54 saved
.75 earned by baby-sitting
_____ needs
$7.95 cost of sweater

Alternate solution using number sentence
3.54 + .75 + n = 7.95

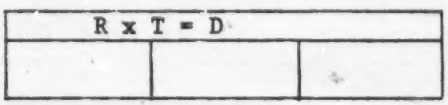
P. Using Diagrams

Directions: Carefully read the problems below. Write the solution to each problem.

1. Find the area of a rectangular room whose length is 10 feet and whose width is 8 feet. (seeing relationship between words and diagrams)

10 ft.

2. Roy drove 30 miles per hour for 4 hours. How far did he drive? (use of formulas)



3. Sam took 6 hours to drive 270 miles. What was his average rate of speed? (alternate use of formula)

$$R \times T = D$$

$$R = \frac{D}{T}$$

O. Telling Number Stories

Directions: Tell a number story for the following number sentences. (transferring numbers and symbols into words, vocabulary symbols)

1. 8 + 3 = 11
2. 20 - 6 = 14
3. 35 ÷ 7 = 5
4. 10 x 5 = 50
5. 9 + n = 17
6. 24 ÷ 2 = n

Directions: Carefully look at the first two numbers in each problem. Use any of the four basic operations (addition, subtraction, multiplication, and division) any number of times to arrive at the last number. There is more than one correct answer for eacn problem. (seeing relationships and drawing conclusions)

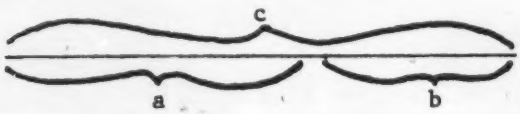
1. 2,4 → 12
   3,2 → 10
   4,4 → 16
   5,4 → 18
2. 3,2 → 5
   4,3 → 7
   8,9 →
3. 7,1 →

   9,7 →
   5,9 →
   6,8 →
4. 3,5 → 10
   8,5 → 16
   7,3 → 14
   6,9 →

R. Creating Formulas

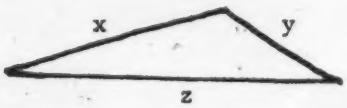
Directions: Use letters and symbols to write a formula--a short way of writing a rule--for each of the following

Example:

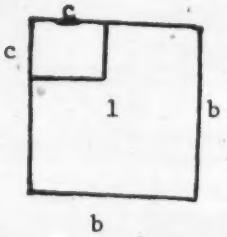


c = a + b

1. In the drawing above, a = _____; b = _____.

2. 

perimeter (P) = _____

3. 

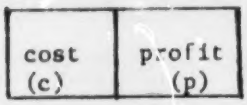
area (A) of section 1 = _____.

4.

a	1	2	3	4
b	3	4	5	6

b = _____

5. Selling price(s)



s = _____

6. The distance (d) traveled equals the rate of travel (r) times the time (t).

MAKING ASSIGNMENTS

Teachers must preview assigned material for new symbols, terms, or operations and explain these carefully to the students. Formats for problems differing from the usual, terminology for operations stated differently, and words with new contextual meanings can be confusing to students. Teachers must also be sure that their instructions are clear and unambiguous.

List of Books on
Content Area Reading

1. Improving Reading in Every Class
   Ellen L. Thomas and H. Alan Robinson
   Allyn and Bacon, Inc., 1973
   Boston, Massachusetts
   Price: $18.95

2. Comprehensive High School Reading Methods
   David L. Shepherd
   Charles E. Merrill Co., 1973
   1300 Alum Creek Drive
   Columbus, Ohio 43216
   Price: $11.95

3. Reading Strategies for Secondary School Teachers
   Lou E. Burmeister
   Addison Wesley Publishing Co., 1974
   Reading, Massachusetts
   Price: $9.95

4. Using Reading to Teach Subject Matter
   Arnold Burron and Amos L. Claybaugh
   Charles E. Merrill Co., 1974
   1300 Alum Creek Drive
   Columbus, Ohio 43216
   Price: $2.95

5. Reading in the Content Areas
   James L. Laffey, Editor
   International Reading Association, 1972
   800 Barksdale Road
   Newark, Delaware 19711
   Price: $6.50 (estimated)

6. Successful Methods for Teaching the Slow Learner
   Muriel S. Karlin and Regina Berger
   Parker Publishing Company, 1969
   West Nyack, New York 10994
   Price: $9.95 (estimated)

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